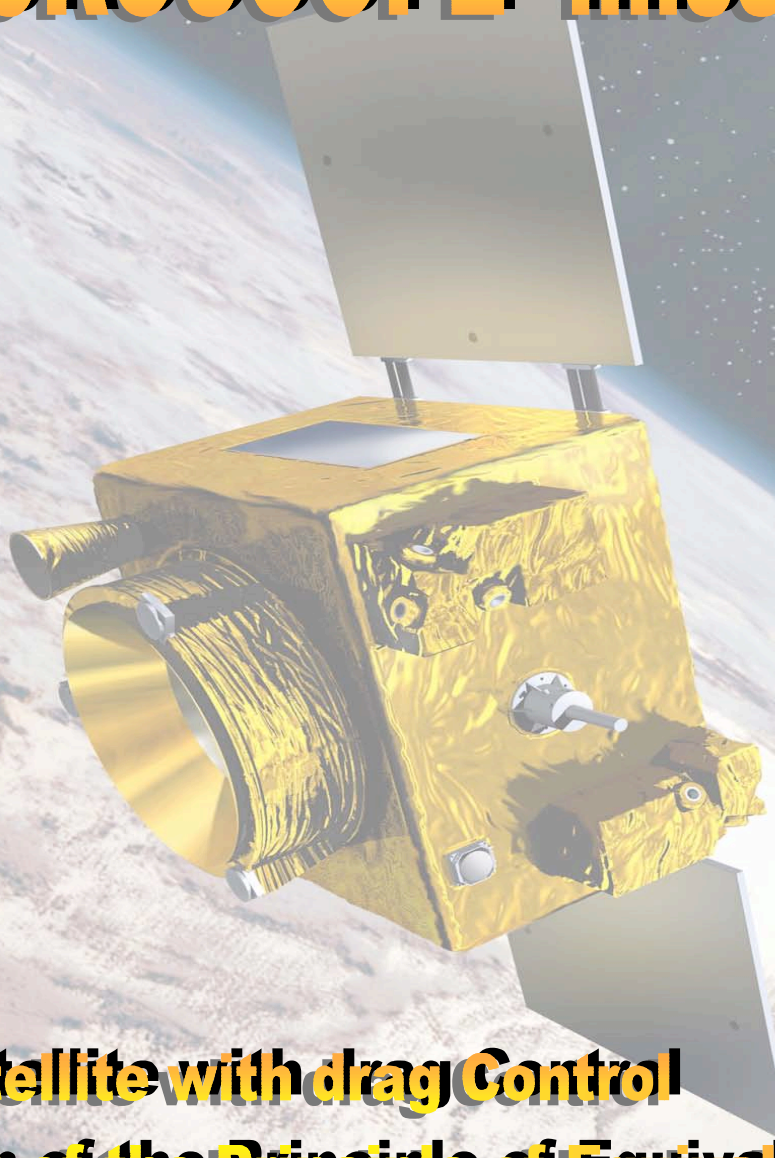
The MICROSCOPE mission



MICRO Satellite with drag Control
for the Observation of the Principle of Equivalence

Context and goal

- CNES satellite project in the series of decided _-satellites (less than 200 kg) proposed by ONERA and CERGA (1999)
- To be launched at the earliest in 2006
- On a circular orbit at an altitude of 700 km about
- For measuring the test of Equilibrium Principle to 10^{-15}
- By the mean of accelerometers of different materials (Titanium-Platinium) in free fall
- Compared to a « test of zero » achieved by another accelerometer couple (Platinium-Platinium)

Physics

- **Experimental fact: gravific mass = inertial mass**

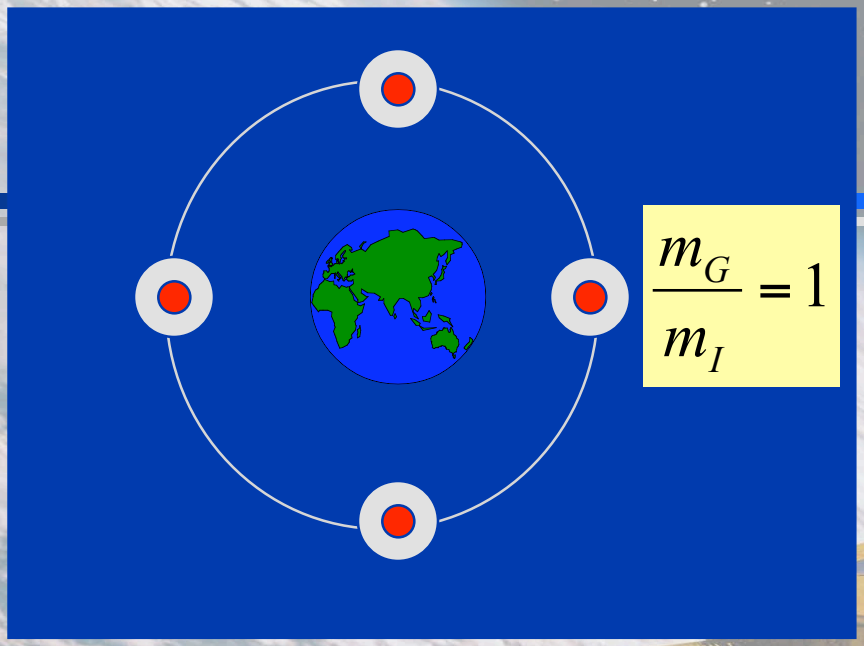
- **Consequence : universality of free fall (Galilei 1564 - 1642, Newton 1642-1727)**

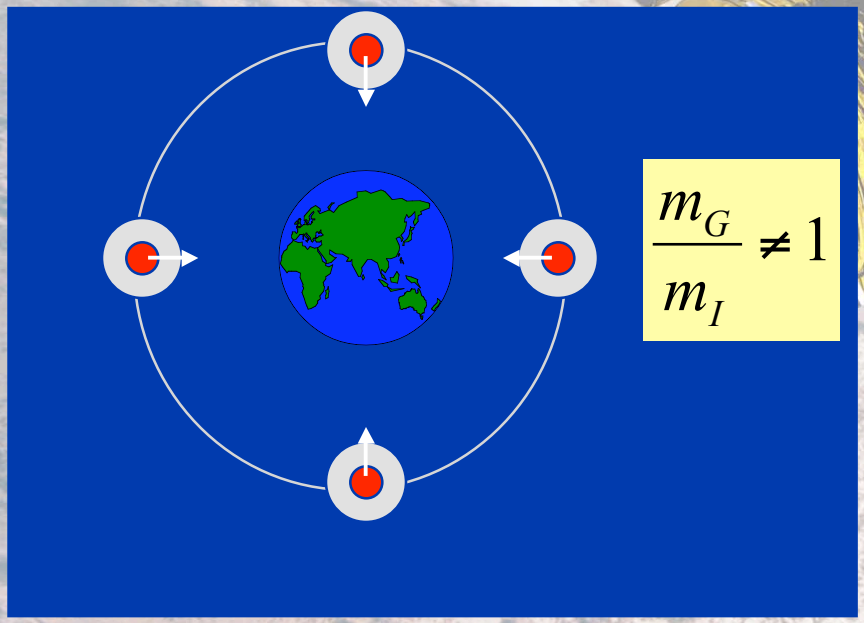
  A plum falls with the same velocity than a piece of lead

  The Moon like the Earth « fall » on the Sun in the same manner : equivalence tested to 10^{-12} by LLR

- **Einstein erected the equivalence: $m_G = m_I$ in a principle as basis of the general relativity theory**

- **But most of actual unification theories of the gravitation (with other interactions) foresee violation of equivalence principle to very weak level (10^{-14} à 10^{-23})**





- **No violation of PE :**
  the 2 masses (red and grey) stay centered naturally.

  inertial mass : $F_I = m_I \square$

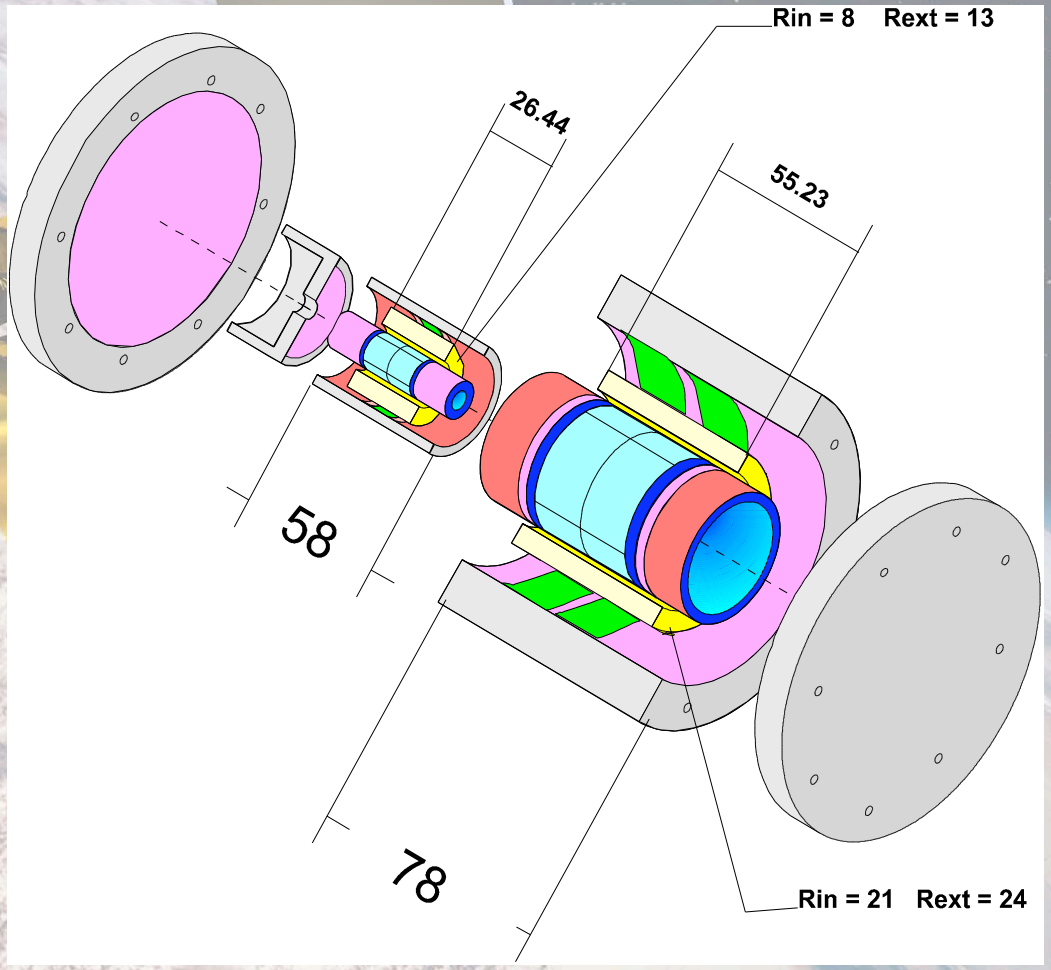
  gravific mass : $F_G = \square \frac{GM m_G}{r^2}$

- **Violation of PE :**
  a force directed toward the Earth must be applied to maintain centering.

Accelerometers (ONERA)

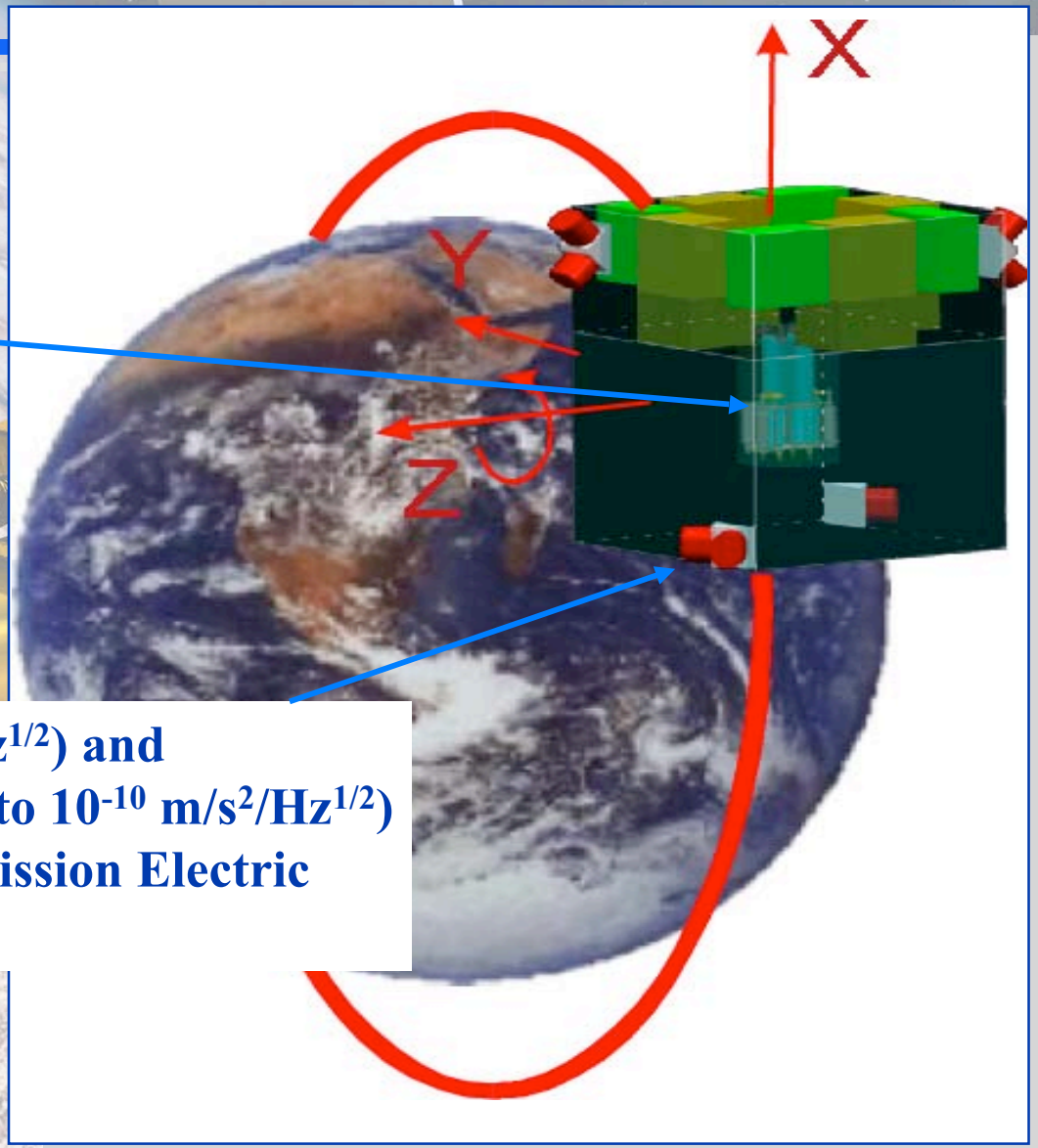
- Test-Masses
- Sensitive axial electrodes
- Spin control electrodes
- Levitation control electrodes
- Electrostatic shield

2 couples of 2 differential cylindrical proof masses about 12 cm apart of the centre of mass :
- one with two different materials: titanium and platinium
- the other one with the same material (platinium)



Instrument performance

Measurements are made by two 3D differential accelerometers in inertial mode or spin mode (to 10^{-10} m/s^2/Hz$^{1/2}$).
PE test is realised at the revolution frequency (to 10^{-12} m/s^2 in X)



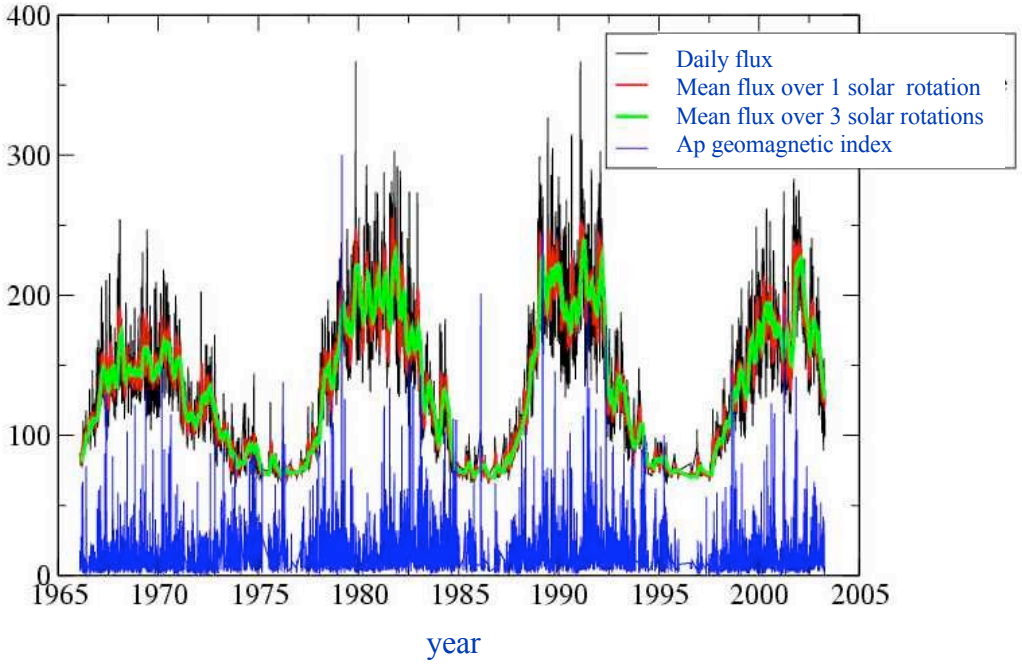
Attitude control (to 10^{-8} rd/s^2/Hz$^{1/2}$) and drag-free compensated system (to 10^{-10} m/s^2/Hz$^{1/2}$) is achieved by FEEPs (Field Emission Electric Propulsion)

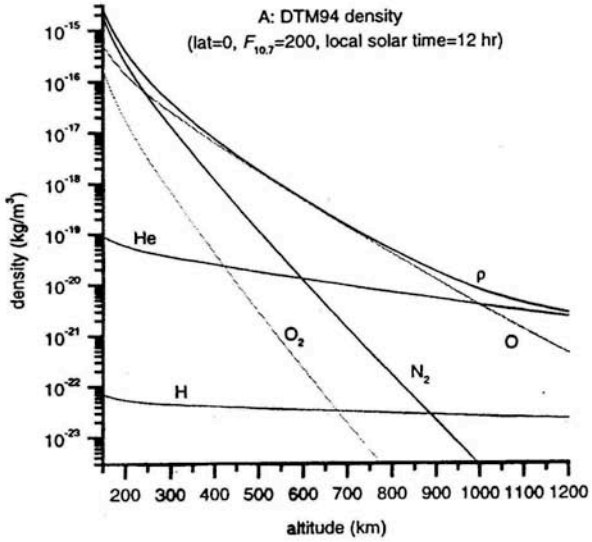
Proposal

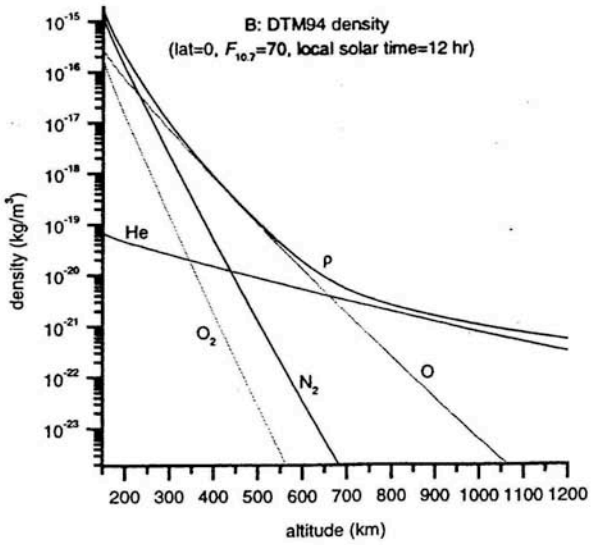
- To equip the satellite with retro-reflectors (6 at all, one on each side of the cubic body)
- To allow a precise (cm) orbit determination (as test of gravity field modeling) as well as an alternative and continuous accelerometer calibration process even without FEEPs activation
- While nominal tracking will be achieved by S-Band system (~100 m precision: not adequate for absolute calibration of accelerometers by orbital technique)
- To complete the thermospheric information (in O and He) beside CHAMP (480 km) and GRACE (580 km) accelerometer missions (covering N_2 and O)

Thermosphere

Solar flux (F10.7) and geomagnetic activity (Ap)







Need

- Continuous tracking from SLR network
- From the beginning of the mission (2006) and at least over its nominal duration (one year) or maybe longer
- To obtain centimetric precision orbit for geodetic purposes and for absolute accelerometer calibration whenever FEEPs are working or not
- But have to be first accepted in phase B by CNES program committee (decision probably in July)
- Question: is there any interest, comment or recommendation of the ILRS community ?